My DIY radio wave energy harvesting circuit

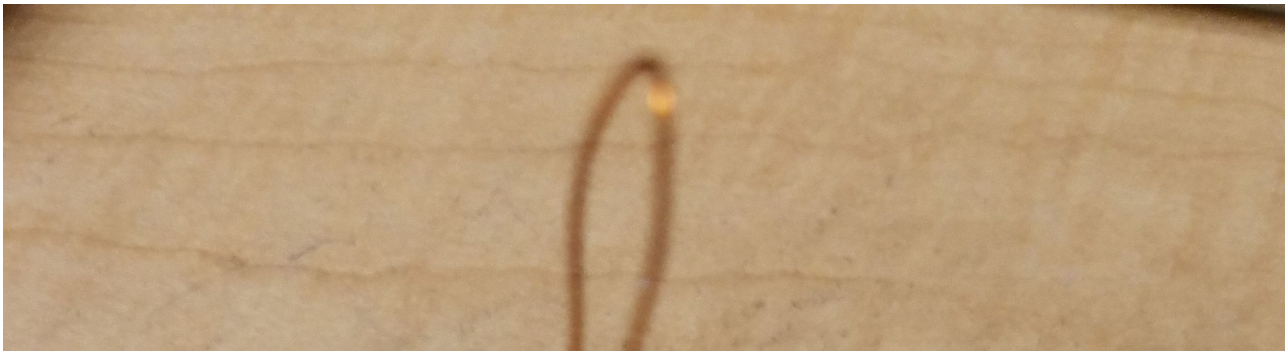
proteus-h (61) **(/@proteus-h)** in **technology (/trending/technology)** • 2 months ago

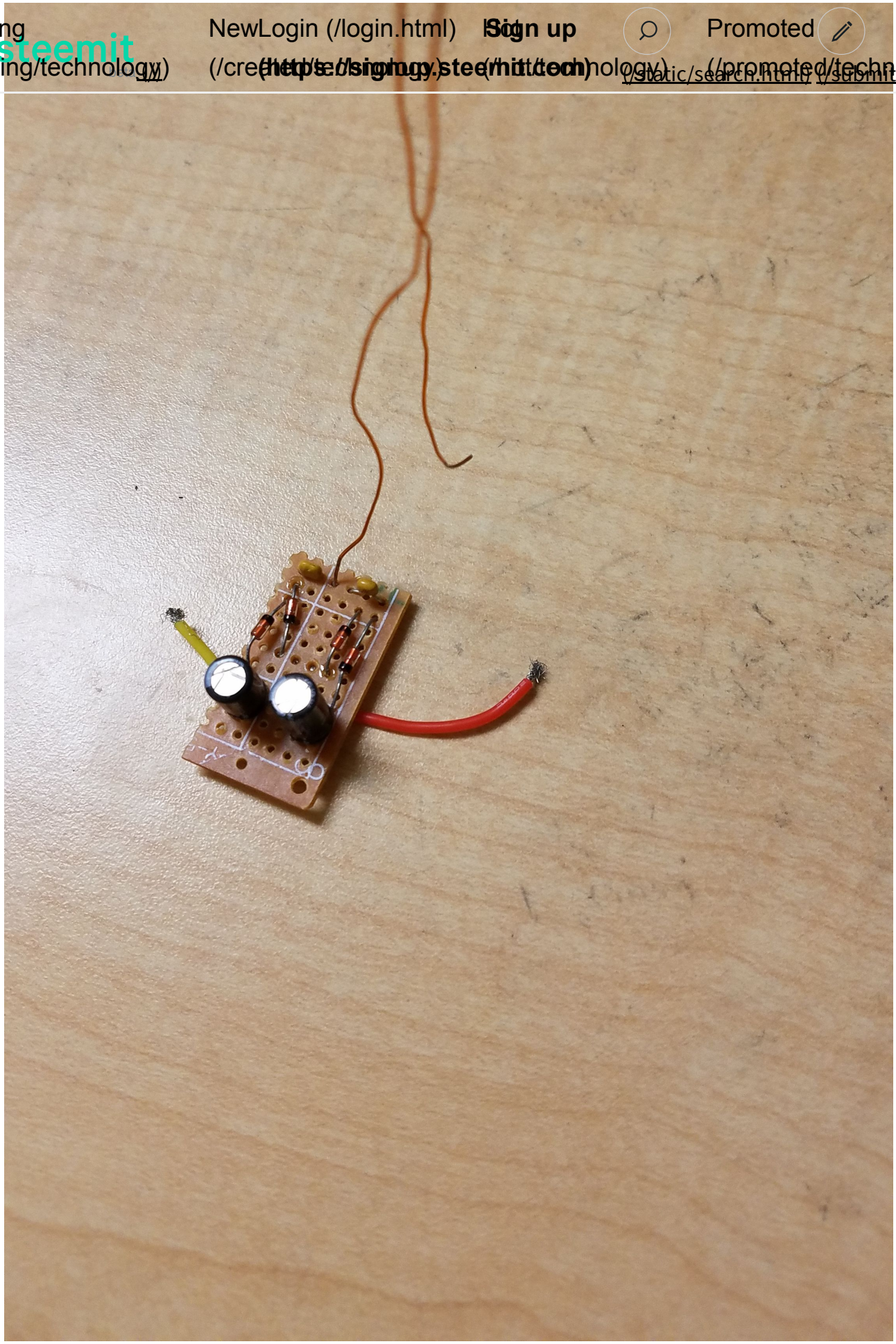
Here's a writeup of a simple radio-frequency energy harvester I built earlier this year. Now that I'm back at my apartment with my equipment I should be able to post more DIY projects. This device is crude, unoptimized, and imperfect ... *but it works*.

This super simple circuit converts radio waves collected into a crude wire antenna into electrical energy which is stored onboard two electrolytic capacitors. This is not a "free energy" device because it actually works: All of the energy brought into the capacitors comes directly from the energy of electromagnetic waves. You can build your very own harvester circuit with just 9 components and a piece of perfboard.

The actual amount of energy collected is absolutely tiny if you are only using ambient RF, so like most of my projects this is just a proof of concept. It's not going to charge a powerbank off of your cell phone emissions or anything like that ...

In case you don't want to get into the details, here's a picture of the completed crude harvester:





Operating Principles

Ambient electromagnetic radiation is all around you, harmlessly emitted from most electronics. Computers transmit 2.4 GHz microwaves for wifi/bluetooth and car FM transmitters transmit around 100 MHz to send audio to your car's radio receiver. Light itself is also, of course, electromagnetic radiation, but this device only works for much lower frequencies. I had the best luck around 100-200 MHz radiation. Electromagnetic radiation at these low frequencies (radio and microwave) is not ionizing and as such harmlessly passes through or is absorbed by your body.

EM radiation can be collected via antennas. Any radio receiver does this but only uses the captured radio wave energy to produce a detectable signal so that you can hear the broadcast. But these waves contain *energy*, and we can capture this energy and use it for other purposes, small as it may be.

Crystal radios (https://en.wikipedia.org/wiki/Crystal_radio), common starter DIY electronics projects, do just this. A crystal radio is a simple receiver that can be built from mostly scrap parts, and lets you listen to radio broadcasts *without a battery*. The crystal radio produces energy out of its piezoelectric speaker: Sound energy, that is. This energy *has to come from somewhere*, and in the crystal radio's case, it is harvested directly from the incoming electromagnetic radio waves.

A crystal radio receiver.
Image credit (https://en.wikipedia.org/wiki/Crystal_radio)

Other devices, such as passive RFID tags, also work by extracting energy from electromagnetic fields.

This device works on the same principle: Extract useful energy from electromagnetic waves. Here's the schematic for the circuit (found by me online - I didn't design this, although it is pretty simple)

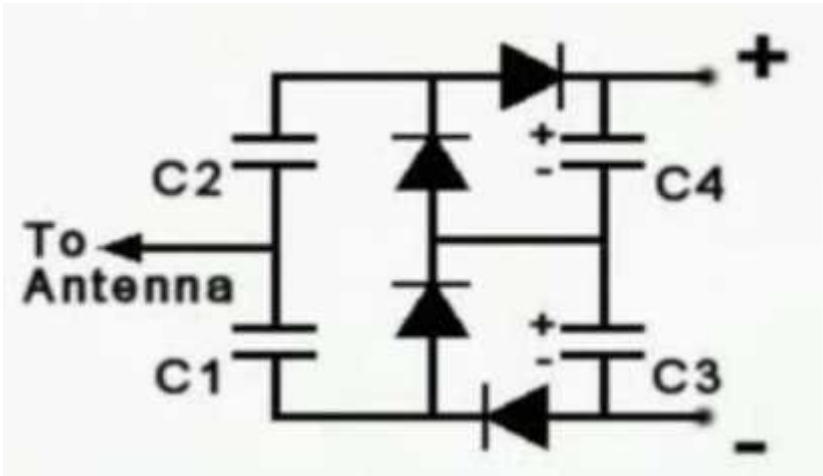


Image credit (https://electronics.stackexchange.com/questions/248525/circuit-for-free-energy-from-radio-waves)

Capacitors C1 and C2 serve to isolate the antenna. The antenna in my case is made from a piece of copper wire soldered to the two capacitors. The wire is probably 20 centimeters long and was not optimized with any particular frequency in mind (this was a quick project). The four diodes form a full wave rectifier that converts the incoming alternating current produced by the inbound radio wave into direct current. Capacitors C3 and C4 then serve to store the harvested energy in an electric field - think of them as tiny batteries. For C3 and C4, I used 100 microfarad capacitors rated to 35 Volts. These are very small capacitors but will store enough energy to easily measure on my cheap multimeter.

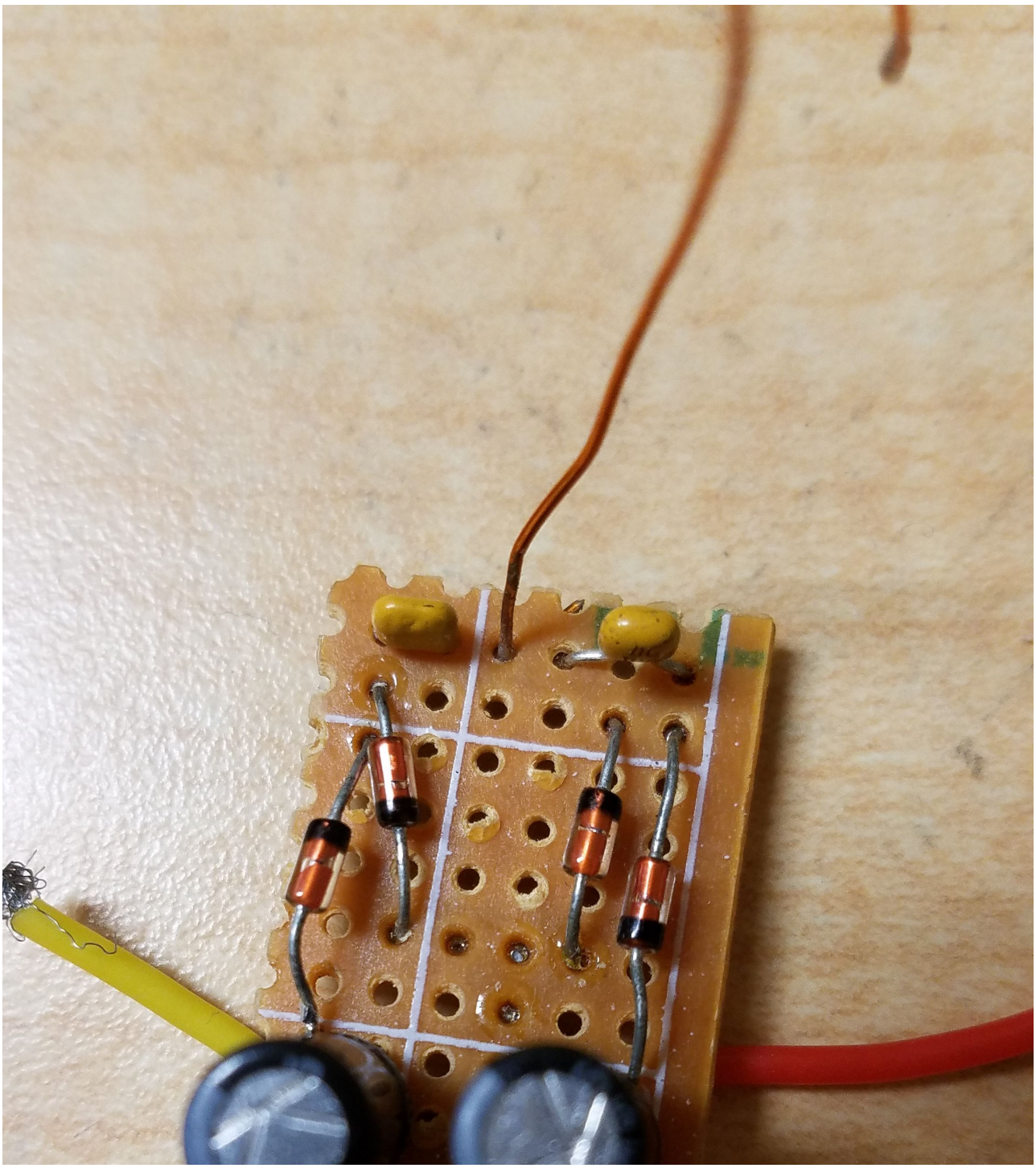
Assembly

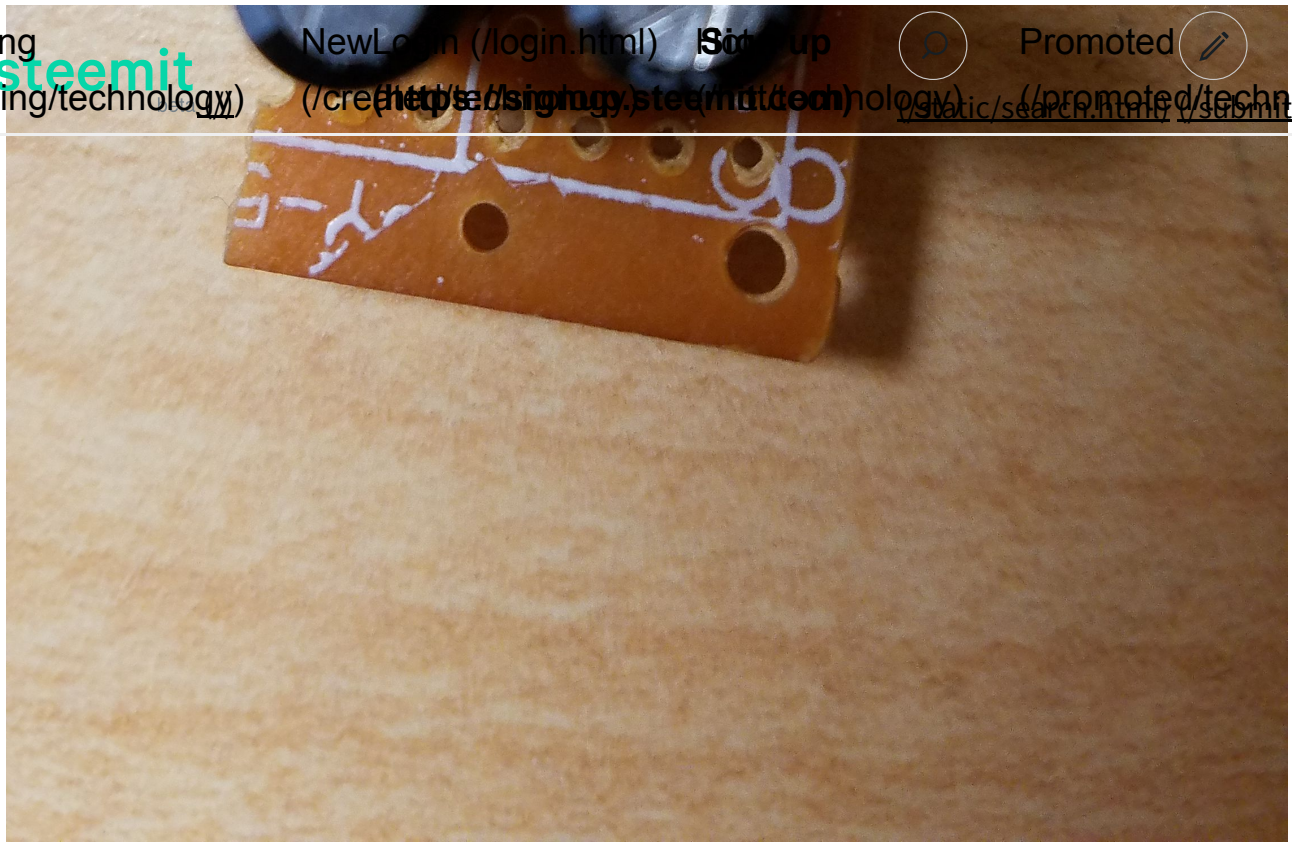
It's important to note that you can't just use any diodes for this and expect it to work. The diodes used need to be able to handle sufficiently high frequency and have a low voltage drop. To handle this task, I used the **1N34A Germanium diode** (I got some on Ebay for a reasonable price). You can peruse the datasheet here. (http://www.nteinc.com/specs/original/1N34A.pdf) In particular, these diodes are used for *FM radio detection* - this is essentially the same thing the energy harvester circuit is doing, since it is rectifying an input signal close to the typical FM band in frequency. Note that although the datasheet states that the forward voltage drop is 1 volt, this drop is much lower at the low currents we are dealing with here.

1N34A Germanium Diode
Image credit (https://www.radioshack.com/products/nte-1n34a-germanium-diode)

For assembly, I used a broken piece of perfboard I had lying around and a soldering iron to quickly connect all of the components. It is critical to get the polarity on the electrolytic capacitors correct. For the two capacitors connecting the antenna to the circuit, I used ceramic capacitors that don't need to be hooked up with a certain polarity. Once again, I used a badly optimized piece of wire as an "antenna" just to see if this would work. I unfortunately don't have the knowledge of RF theory yet to go much further, but the wire ended up working out just fine.

Here is a close-up shot of the final circuit. Yeah, I know it's ugly.



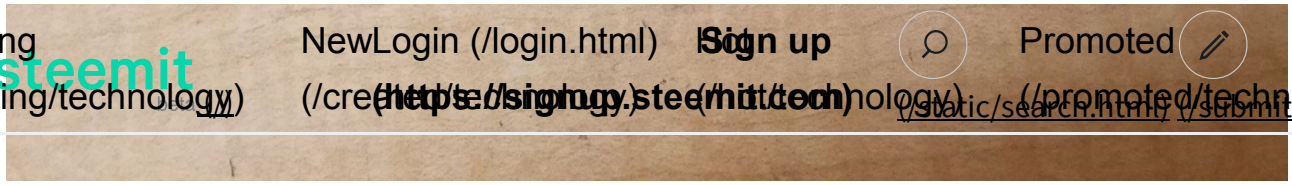


The red and yellow wires are just to make it easy for me to read the voltage on the storage capacitors - they are completely unnecessary.

I originally expected to get tiny (but detectable) energy generation, picked up on C3 and C4, just by leaving the circuit out in the room I built it in. When this didn't work, I thought it was broken. Turns out it wasn't: A ham radio transmitter confirmed that.

Using a Baofeng UV-5R handheld radio transmitter on the VHF band (~140 MHz) near the harvester causes the storage capacitor voltage to spike - so much so that I would be worried about them failing if the transmitter was left on for more than a few seconds. In a test I just did a couple minutes ago, quickly transmitting around 142 MHz (4W transmit power, nobody was using that frequency at the time) from a few inches away from the harvester caused the storage capacitors to quickly spike up to over 16 volts - not insignificant at all. This voltage was measured across the two electrolytic capacitors in series. In fact, this is easily enough to light an LED for a brief moment (or even break it, since LEDs are typically not rated for 16 volts).


VFO/MR
A/B
BAOFENG
BAND
MENU
EXIT
1 STEP
2 TXP
3 SAVE
SCAN
4 VOX
5 WN
6 ABR
0 SQL
7 TDR
8 BEEP
9 TOT
UV-5R



My UV-5R transceiver. I used this handheld to test the harvester circuit above. If you're looking to get into ham radio, I highly recommend this device because it's very cheap (~$25), is somewhat sturdy, and offers UHF and VHF transmission/reception.

The UV-5R transmitter proves conclusively that the harvester is actually working ... somewhat. While you can harvest pretty decent amounts of energy an inch away from a four watt radio transmitter, this isn't useful outside of an experiment since ambient RF is nowhere near that energetic. Detecting ambient RF with this thing would be nice ...

Well, I was able to do that too with this circuit. I just conducted another test where I shorted the storage capacitor and measured the storage capacitor voltage after 1 minute. The result: 18 millivolts. Here's the multimeter screen:

Various other informal tests returned similar results. For some reason, the circuit does actually harvest tiny amounts of energy from radio waves in my apartment but not in the room where I originally built the circuit. Not sure why there is more RF here, but whatever. The capacitors hooked up to the harvester charge themselves without external power source ... other than the radio waves transferring energy to the circuit, of course, to conserve energy.

Of course, 18 millivolts (that's 0.018 volts ... you should be laughing here) is pretty damn useless. But once again, this isn't exactly intended to be a useful product. There really isn't a lot of energy in ambient RF waves